Detection of CH_4 Hotspots from NASA's GEOS Composition Analysis System

Nikolay Balashov (1, 2), Brad Weir (2, 3), Lesley Ott (2), Sourish Basu (1, 2)

(1) Earth System Science Interdisciplinary Center, University of Maryland, College Park, MD
(2) Global Modeling and Assimilation Office, NASA Goddard Space Flight Center, Greenbelt, MD
(3) Morgan State University, Baltimore, MD

GMAO
Global Modeling & Assimilation Office
A43R-3013

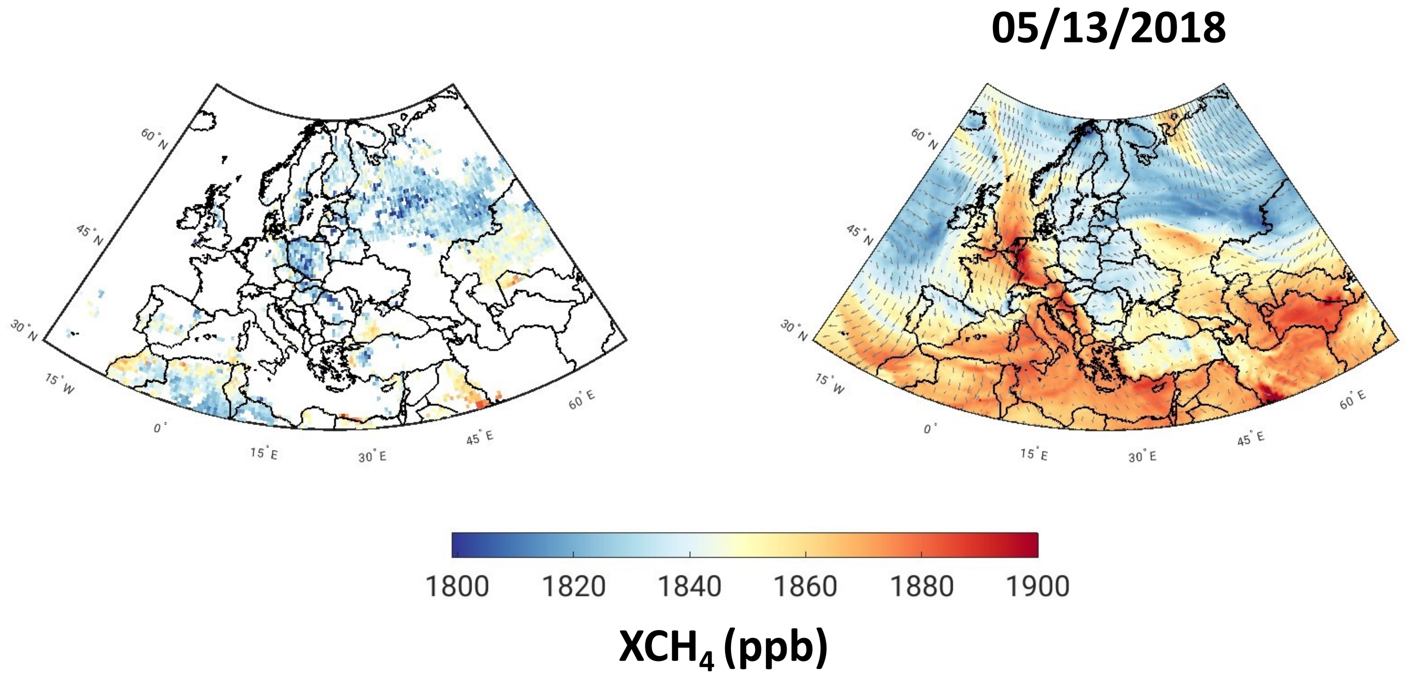
Motivation

- About 8-12% of the global oil and gas production methane (CH_4) emissions could be attributed to ultra-emitters, which result in high concentration 'hotspots' near point sources (*Lauvaux et al., 2022*).
- Identifying these emissions in near real time provides useful information to the policy makers and private industry, who are working to reduce their impact.
- ***Reference:*** *Lauvaux, T., Giron, C., Mazzolini, M., d'Aspremont, A., Duren, R., Cusworth, D., Shindell, D. and Ciais, P., 2022. Global assessment of oil and gas methane ultra-emitters. Science, 375(6580), pp.557-561.*

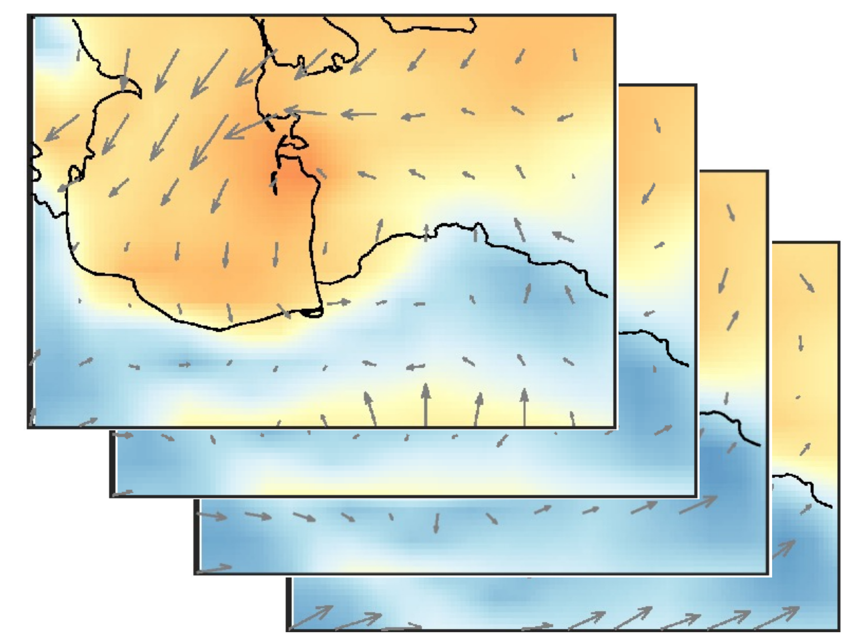
Objectives

- To explore possible methodologies to detect CH_4 hotspots using a new, gap-filled, and temporally continuous methane product from NASA's Goddard Earth Observing System (GEOS) Constituent Data Assimilation System (CoDAS), which assimilates column averaged methane mole fractions (XCH_4) from the TROPOspheric Monitoring Instrument (TROPOMI).
- Figure below illustrates advantages of gap-filled NASA GEOS CODAS vs. TROPOMI, where the NASA product provides improved spatial and temporal coverage of XCH_4.
- Before working with assimilated data, two GEOS XCH_4 simulations with different resolutions are used to test methodologies for estimating already known hotspots.

TROPOMI XCH_4 on 05/13/2018 | **NASA GEOS XCH_4 with TROPOMI Assimilated at 21 UTC on 05/13/2018**



Collection of 3-hourly Instances of GEOS XCH_4



Self-Organizing Maps (SOMs)

- To transform a collection of model output instances into a few distinct patterns a **Self-Organizing Map (SOM)** is utilized, which is an unsupervised machine learning algorithm used for clustering and visualization of high-dimensional data.
- The goal of the procedure is to identify model outputs showing well-structured plumes that are then could be used to estimate emissions.
- This type of identification has a better chance of bringing potential **hotspots** to attention.

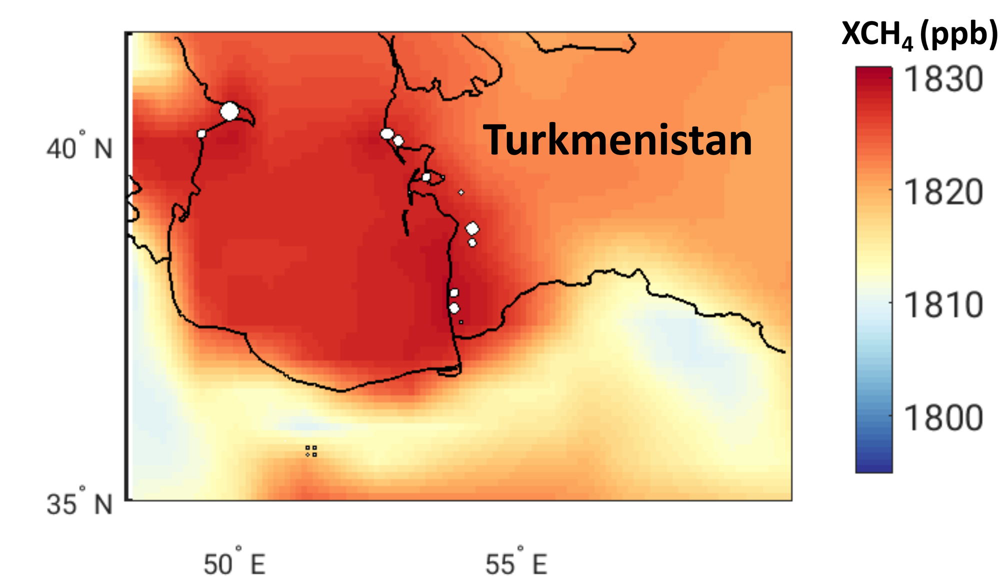
- Once the appropriate pattern is identified, outputs that contributed to that pattern are used for emission calculations.
- For each output, a background is calculated for each pixel by taking median of 1 degree surrounding patch (*Lauvaux et al., 2022*).

- When background is subtracted from a selected output, enhancements from plumes remain, which are then used for hotspot emissions calculations.

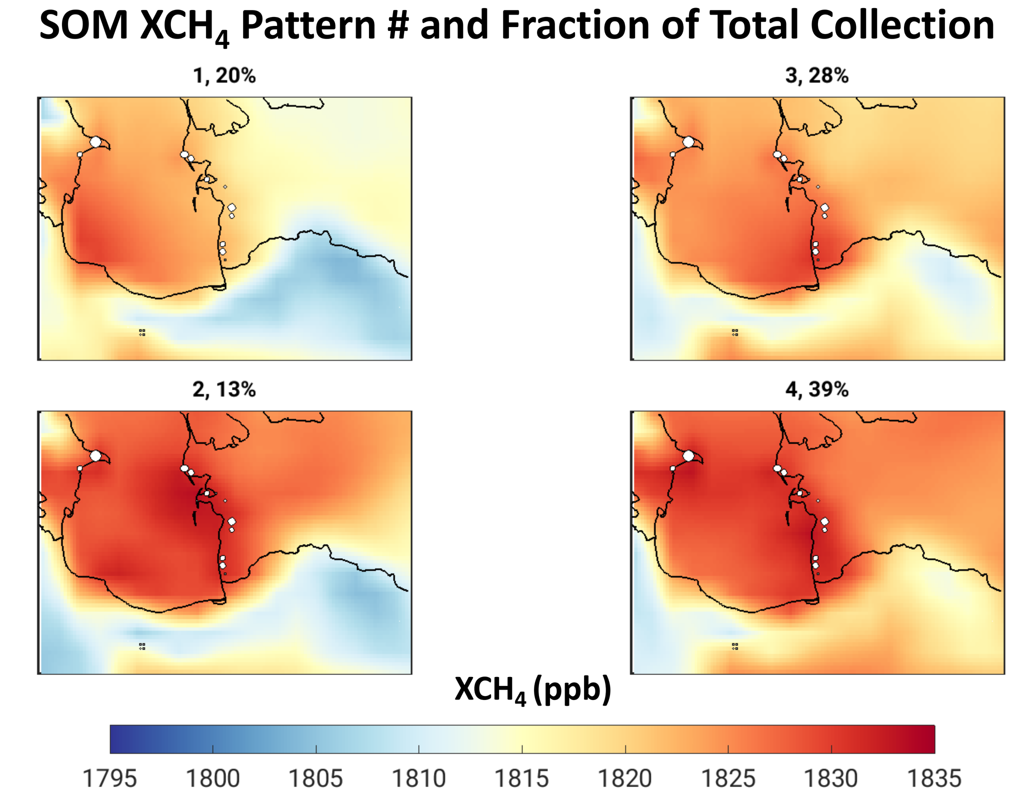
$$Q = \frac{U_{eff}}{L} \sum_{i=1}^{N} \Delta\Omega_i \Lambda_i$$

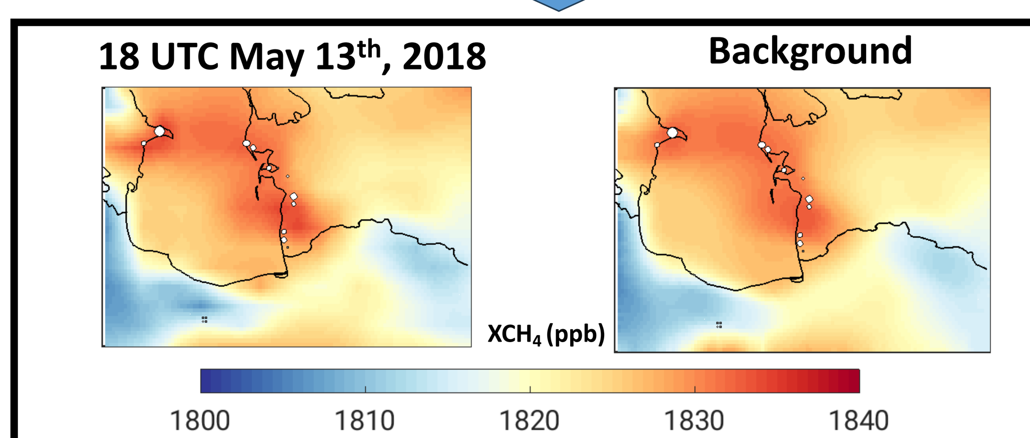
U_{eff} – wind speed
L – characteristic plume size
$\Delta\Omega_i$ – pixel plume mass enhancement
Λ_i – area of a pixel
N – number of pixels in a plume
Q – CH_4 emissions in kg/hr

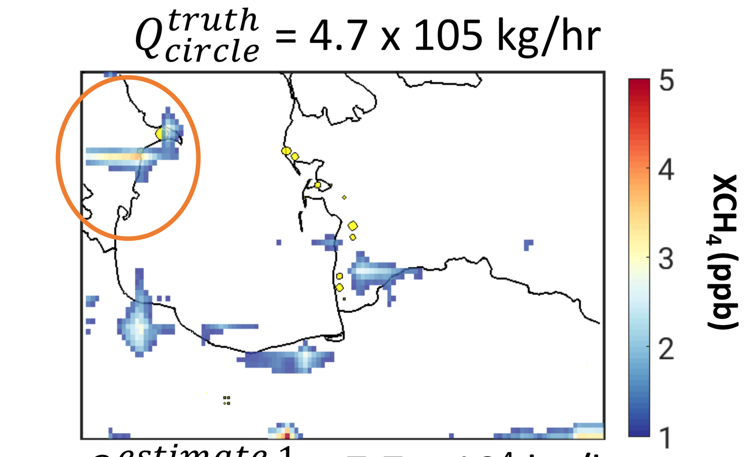
GEOS 0.5x0.625 XCH_4 3-h Collection Averaged over May 10-20, 2018 (in ppb)



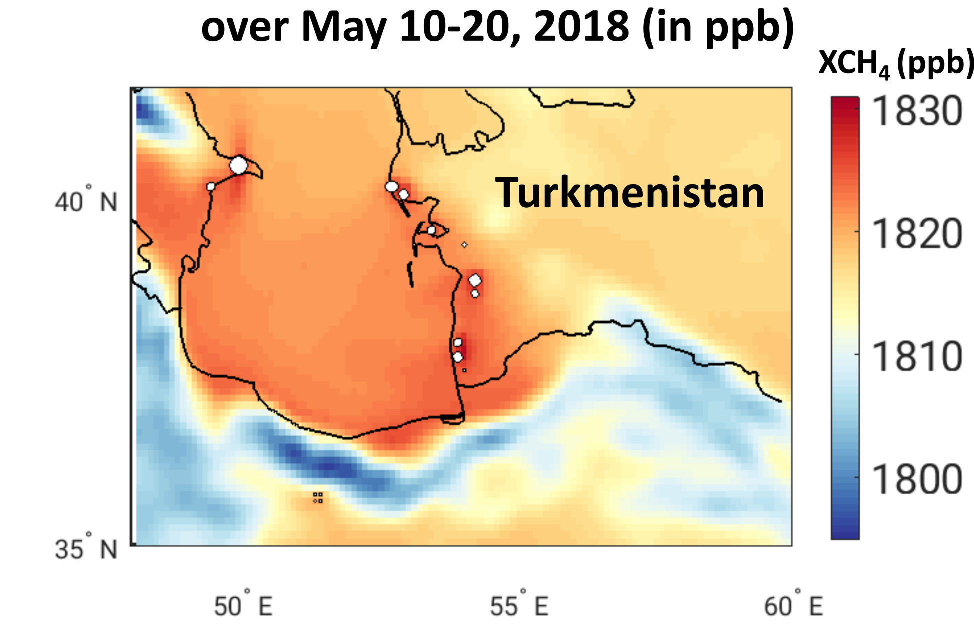
SOM XCH_4 Pattern # and Fraction of Total Collection



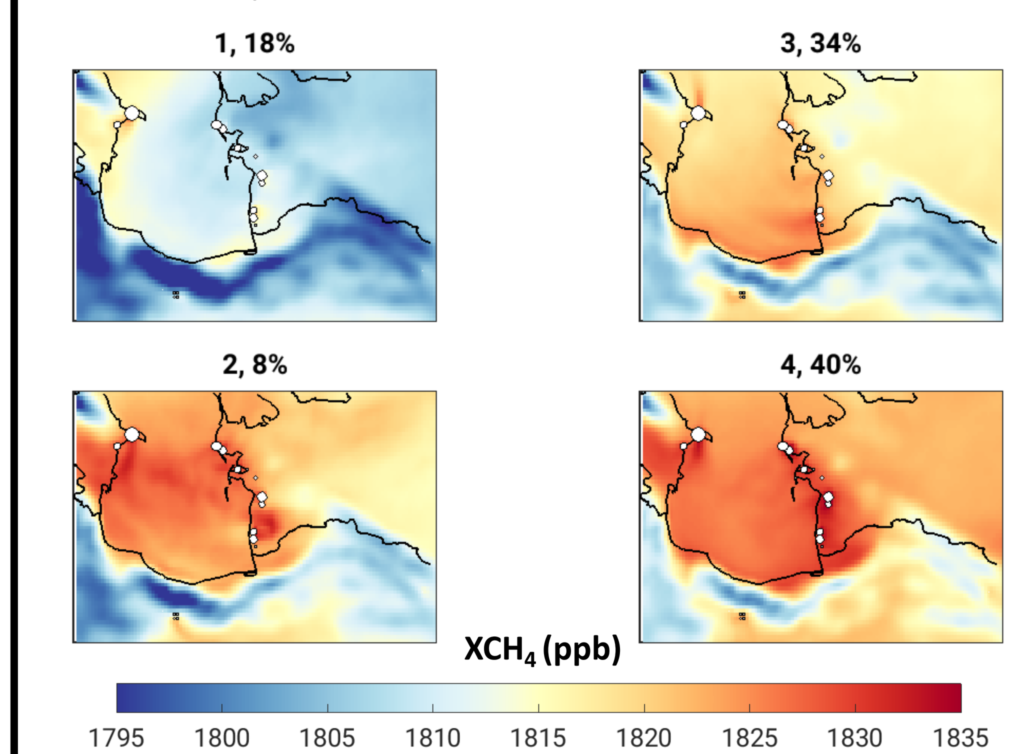


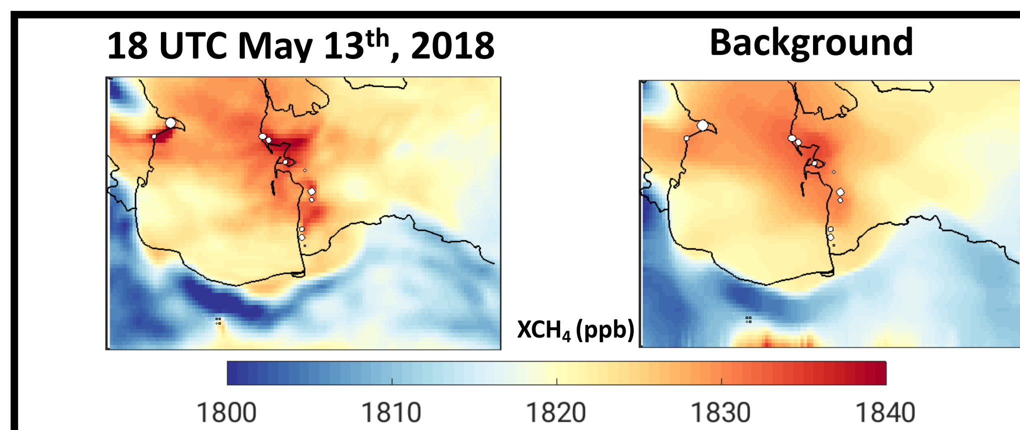


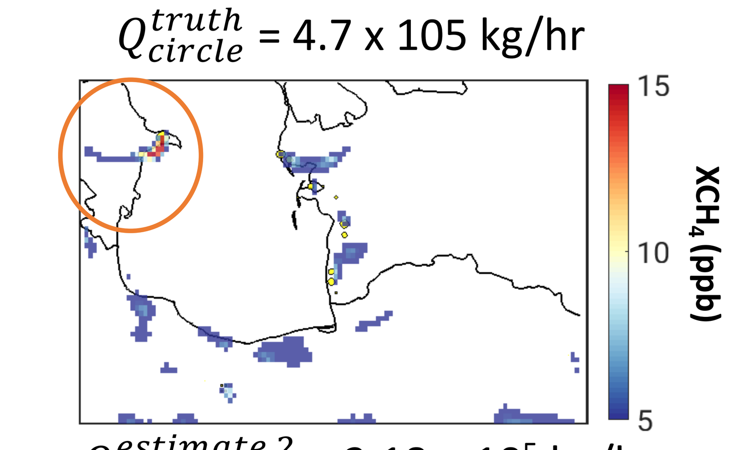
GEOS 0.125x0.125 XCH_4 3-h Collection Averaged over May 10-20, 2018 (in ppb)



SOM XCH_4 Pattern # and Fraction of Total Collection







GODDARD EARTH SCIENCES

E-mail: nikolay.v.balashov@nasa.gov | Web: gmao.gsfc.nasa.gov

University of Maryland 1856
EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER

National Aeronautics and Space Administration
NASA